PROPERTIES OF BATTERIES

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A. GENERAL INFORMATION

1. There are several different kinds of batteries in use today throughout DoD. Their construction and/or chemistry differs from one type of battery to another. For example, a battery may consist of a single cell (a typical flashlight battery) in the most general sense, or several cells (a 6-cell automobile battery). An individual cell will consist of a metal which tends to release or give up electrons (the anode), another metal which tends to attract to or accept electrons (the cathode), and an electrolyte, which acts as the cell's mediums for the condition or flow of current. If the electrolyte is a liquid (e.g., sulfuric acid), the battery is categorized as a "wet cell". If the electrolyte is a paste or semi-solid which does not behave like a fluid (as in most carbon-zinc batteries), it is considered to be a "dry cell".

2. Batteries may also be categorized as either primary (nonrechargeable) (FSC 6135) or secondary (rechargeable) (FSC 6140). The primary battery cell is designed to convert chemical energy into active, electrical energy irreversibly. It should be noted that primary cells normally cannot be recharged and that attempts to do so could result in leaking of contents, venting, or explosion. The secondary battery cell, however, is both reversible in transformation and also rechargeable. Secondary batteries are commonly called storage batteries. Both primary (e.g., Lithium-Sulfur dioxide) and storage (e.g., lead-acid) batteries are described in the second part of this section.

3. See enclosure 1 for the definitions of terms in paragraphs a and b.

B. HAZARDOUS PROPERTIES INFORMATION

1. **Carbon-Zinc (Leclanche) Batteries**

a. This type of battery often consists of one dry cell. It is used in such everyday devices as flashlights, portable radio sets, etc. Most likely the battery will consist of a zinc can (anode), a centrally located carbon rod (cathode), and an electrolyte paste of ammonium chloride, zinc chloride, and maganese dioxide.

b. When corroded, these batteries may be hazardous to personnel. As a solid, zinc is a skin irritant. Seeping ammonium chloride is also a skin irritant.

2. **Lead-Acid Batteries**

a. The most commonly known battery is the lead-acid storage battery used in automobiles and other motorized vehicles. It is both rechargeable and of the "wet" variety (usually six-celled). Inside each cell are plates made of sponge lead (anode) and lead dioxide (cathode), immersed in a sulfuric acid electrolyte. Although one would seldom handle the inner parts of the battery itself, DRMO personnel should remember that lead and lead dioxide are toxic whether ingested or inhaled as dust or fume. The primary danger with the battery, however, rests with the sulfuric acid electrolyte, often referred to as "battery acid". Not only is the chemical highly corrosive, but it is also a strong irritant to the skin and reacts exothermically with water. Special personal protective equipment to be used when handling these batteries are outlined in Chapter XXI, paragraph C3a. The liquid electrolyte in most storage batteries (most notably sulfuric acid in automotive batteries) is hazardous because it is corrosive.

b. The sealed automotive battery is a special type of lead acid battery. Some of these batteries are either hermetically sealed or so constructed that to obtain access to the electrolyte would require breaking the case. Since it has its electrolyte securely encased, cell leakage or spillage is very unlikely to occur. Other purportedly "sealed" batteries, however, can be opened by simply unscrewing the covering and cell caps.

3. **Lithium - Sulfur Dioxide Batteries ($LiS0_2$)**

a. The lithium primary battery is used in DoD as a power source for portable electronic equipment, missiles, mines, sonobuoys, and torpedoes. Its advantages over other primary cell systems include high current density, consistently high voltage, light weight, and an ability to operate at low temperatures.

b. The high reactivity of lithium metal, however, creates a potential hazard. Depending on the proportion of lithium to sulfur dioxide, the battery's chemistry is considered either as "balanced" (2.6 - 3.0 grams Li to 23.5 - 24.5 grams SO2) or "unbalanced" (4.2 grams Li to 24.5 grams SO_2). In the unbalanced variety, lithium metal can react with the electrolyte in the absence of sulfur dioxide to produce lithium cyanide, heat, and methane gas, which may cause rupturing; therefore, this battery has been documented to be a potential safety hazard. For this reason, handling and disposal of these batteries are of particular concern to DoD and DRMS. In fact, DRMS has informed the Military Services that DRMOs will only take physical custody of lithium - sulfur dioxide batteries which the turn-in activity identifies as "balanced".

c. Both varieties of $LiS0_2$ batteries consist of the following:

(1) Hermetically sealed nickel plated steel casing.

(2) Over-pressure relief devices (vents) to prevent rupturing and internal fuses to prevent short-circuiting and overheating.

(3) Lithium anode.

(4) Carbon cathode, consisting of an aluminum support screen and a carbon or acetylene black/Teflon mixture.

(5) Electrolyte of acetonitrile, sulfur dioxide, and lithium bromide, all potentially hazardous.

d. Vented or leaking batteries may release sulfur dioxide gas (toxic), lithium hydroxide (corrosives), and methane gas (flammable). Some unbalanced batteries are also reported to have released cyanide when disposed of improperly.

4. **Magnesium-Carbon Batteries**. Often used in field radios, the magnesium-carbon battery is nonrechargeable and usually a dry cell. Its chemical components include primarily magnesium dioxide (which is moderately toxic and may ignite organic materials), magnesium perchlorate (which is a fire and explosion risk in contact with organic materials), and magnesium perchlorate carbon black, according to Sax's Dangerous Properties of Industrial Materials.

5. **Mercury Batteries**

a. This is a primary dry-cell battery found in various portable electronic equipment. Its component parts typically consist of a zinc anode and a mercuric oxide cathode (which may be mixed with graphite). A common electrolyte is potassium hydroxide saturated with zinc oxide. With carefully purified and balanced amounts of the two oxides, the cell makes effective use of its active materials.

b. The dangers of the mercury battery are still being documented. For example, cases of defective mercury batteries bulging or venting have been reported in DoD. These batteries are BA-1100/U, purchased under contract numbers DAABO7-77-6328, DAABO7-77-D-6125, and DAABO7-76-D-6352. Most of these batteries are commonly used in night-vision sight equipment.

6. **Nickel-Cadmium (NICAD) Batteries**

a. NICAD batteries are known to function throughout a wide range of temperatures, possess minimum weight, and are powerful enough to assure the nonassisted starting of engines. Therefore, they may be used in airplanes or helicopters as a standby source of electrical energy. Usually, they are rechargeable and can be rebuilt into serviceable batteries, thus making them generally worth several times the value of the nickel component contained in the plates. There are also small, pocket-size NICAD batteries in use.

b. As the use of the NICAD battery varies, so does the physical state of its electrolyte, potassium hydroxide, which may be in either "wet cell" or "dry cell" form. In either case, potassium hydroxide is a strong base that will corrode many materials and attack the skin. Furthermore, the cadmium cathode itself can be highly toxic, especially if inhaled as dust or fume.

7. **Silver-Bearing Batteries**. Some batteries turned in for disposal contain silver. These include the silver oxide cell battery as well as the alkaline zinc battery. Further, they may be either primary or secondary, usually with a potassium hydroxide electrolyte.

8. **Thermal Batteries**

a. Thermal (heat activated) batteries have been used for many years in various weapons and ordnance items. The batteries use inorganic salt electrolytes that are nonconductive solids at ambient temperatures and an integral pyrotechnic mixture sized to generate enough heat to melt the electrolyte and permit the battery to deliver high power for relatively short durations.

b. Thermal batteries are a RCRA hazardous waste. This determination pertains to both discharged (i.e., fired) or undischarged batteries that cannot be fired, but that require disposal action.

(1) Thermal batteries with calcium/calcium chromate electrochemical system exhibit the RCRA of Toxicity Characteristic.

(2) Thermal batteries with lithium/iron disulfide electrochemistry exhibit the RCRA characteristic of reactivity.